FLASH BEHAVIOR OF A NOVA SCOTIAN FIREFLY, *PHOTURIS FAIRCHILDI* BARBER, DURING COURTSHIP AND AGGRESSIVE MIMICRY (COLEOPTERA, LAMPYRIDAE)[1]

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ABSTRACT

Photuris fairchildi Barber was the only *Photuris* firefly found in Nova Scotia and was common in most moist habitats. Males usually produced single flashes, but in some localities they produced 3- and 4-pulsed flash patterns; flash patterns of individual males varied from 1 to 6 flashes but the pause (time from end of one flash pattern to the beginning of the next) was relatively constant (2.4 to 2.6 sec). Females answered male flash patterns at delays of about 1.5 sec. As the male approached the female, the number of flashes in each male flash pattern and in each female response increased and the flashing of both soon became continuous. The entire dialogue lasted 10-20 sec. Females also answered flashes of other fireflies: *Pyractomena linearis* Leconte, *Pyractomena borealis* (Randall) and *Photinus ardens* LeConte and ate those attracted (aggressive mimicry). Aggressive mimic responses were single flashes and *Photuris* males apparently avoided their predatory females by landing only for responses that include a series of flashes.

INTRODUCTION

Barber (1951) believed that flash behavior of *Photuris* fireflies was species specific and described a number of new species, including *Photuris fairchildi,* largely on this basis. Subsequently, flash signals were found to function in courtship (pair formation) and they reproductively isolated different firefly species (Lloyd 1966). Most North American fireflies use flash-answer communication in courtship (Lloyd 1971). However, the flash communication utilized by *Photuris* fireflies in courtship is still largely a mystery. Courtship flashing in *Photuris divisa* LeConte involved flash-answer signals (Buschman 1972). Females of many other *Photuris* species utilize flash-answer signals to attract males of other firefly species and prey on those attracted (aggressive mimicry, Lloyd 1965; 1973). Courtship flashing has not yet been reported in these fireflies. In this paper I describe the flash behavior of *Photuris fairchildi* during courtship and during aggressive mimicry.

These observations were made during the summers of 1968 and 1969 in the vicinity of Bridgewater, Lunenburg Co., Nova Scotia. *Photuris* fireflies were also noted in Kings, Halifax and Colchester counties. They were common in moist habitats such as marshes and spruce forests. Adults were observed from mid June to late July.

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Taxonomic Considerations

Initial observations suggested that there might be several species of *Photuris* fireflies in Nova Scotia. Several flash patterns were observed in different localities and among individuals within these populations. The flash patterns included 1 to 6 flashes and were repeated about every 2.5 sec. However, the following observations indicated that there was only 1 species, *Photuris fairchildi*: 1) I found no correlation between flash pattern and kind of habitat or geographic distribution. 2) The flashing repertoire of individual fireflies often included most of the flash patterns observed at that location. The following is a list of the number of pulses per flash pattern observed in individual fireflies: 1 only; 1 and 2; 1, 2 and 3; 1, 2 and 4; 2 and 3; 3 only; 3 and 4; 4 only; 4 and 5; 6 only (this list was compiled from several localities). In addition the number of flashes often increased as the male approached an answering female or flashlight (described below). 3) Analysis of flash patterns revealed that the pause (time from the end of one flash pattern to the beginning of the next) was fairly constant (see Table I). For example: when the duration (time between first and last flash of a flash pattern) of 3-pulsed flash patterns (0.82 sec) is subtracted from the interval (time from first flash of one flash pattern to the first flash of the next) following 3-pulsed flash patterns (3.3 sec) the remainder or pause (2.48 sec) is about equal to the pause or interval between single pulsed flash patterns (2.38 sec). Comparison (by analysis of variance and Scheffe's test) of the intervals following similar flash patterns by different individual fireflies revealed no significant difference (= .05). 4) The flash exchange between male and female leading to copulation was observed for single and 4-pulsing fireflies. I observed no differences in the dialogue beyond the initial difference in flash pattern (described below).

Photuris fairchildi was described from specimens and observations sent from Baddeck, Nova Scotia, by Graham Fairchild (Barber 1951). My observations agree with those of Fairchild (Barber 1951): "they were caught over marshy ground" and "they fly rapidly and emit two medium flashes separated by an interval about twice as long as one flash, *but . . . the flashing* [*was*] *not very regular*" (emphasis mine). I did not find any populations in which double flashes predominated; however, the variability I observed would suggest that such populations probably occur.

The behavior of 2 fireflies was unusual but I lacked sufficient data to determine if they were *Photuris fairchildi*. In Bridgewater and near Middle Musquodoboit I observed single males producing 6-pulsed flash patterns in demes where single pulsed flash patterns were common. This was atypical because all other 4- or 5-pulsed flash patterns were observed in predominantly triple pulsing populations.

Courtship Flashing

The flash exchange between male and female leading to copulation was observed on 2 occasions. First, in a locality in which most males were producing single flashes, a flying male flashing at 3.0 and 2.8 sec intervals received a response flash from the vegetation about 10 ft away. The response was a single flash at a delay of about 1.5 sec. The male turned, flew in the direction of the response and flashed again. He received a similar response. The next male flash pattern had 2 flashes, the second being dimmer than the first. The male landed about a foot from the female and produced a 3-pulsed, then a 4-pulsed flash pattern as he moved toward the female. At the same time the number of flashes in the female response increased each time. The number of flashes produced by each increased until they were both flashing at the same time and I could no longer detect a response interval; the flashing was nearly continuous. They met under a leaf and stopped flashing. When I turned the leaf over, they fell to the ground in copulation, male dorsal to the female. A second male nearby began flashing and climbing around during this exchange in a manner similar to the first male. Later in the same vicinity another male and female exchanged flashes as described above except, that after the male landed and approached, the female response decreased and she began moving about; they did not meet. The second observation of flash exchange leading to copulation was in a location where most males were flashing 3 or 4 pulsed flash patterns. A male producing 4 pulses received a response flash from the vegetation 2 ft below him. The next male flash pattern was a long series of flashes. The female began flashing during this series of flashes and both were flashing continuously when the male landed about 0.5 inch from the female and mounted her. The whole sequence took less than 10 sec. On another occasion in this location, flash exchanges were observed between 2 flying fireflies. Again the number of flashes each produced increased as they approached each other. They flew to a tree and landed. I was unable to collect this pair to confirm mating or sexes.

Male *Photuris* fireflies were observed to approach random, repeated or answering flashlight flashes and both male and female *Photuris* flashes. Sometimes they would land and climb onto an answering flashlight, but more often they would approach, hover several feet away and repeat the flash pattern several times before flying away. As males approached a source of

Table I: Characteristics of male *Photuris fairchildi* flash patterns. Measurements were obtained by following individual fireflies and verbally recording their flashes with a tape recorder. The duration (time between first and last flash of a flash pattern) and the interval (time from first flash of one flash pattern to the first flash of the next) were later measured from the tape playback using a stopwatch. These measurements were then grouped according to the number of flashes in the first flash pattern. The pause (time from the end of 1 flash pattern to the beginning of the next) was obtained by subtracting the duration from the respective interval. Thirteen of 29 fireflies produced more than 1 kind of flash pattern.

Flash no. per flash pattern	interval (sec)	no. of measurements	duration	no. of measurements	pause (sec)
1	2.38*	148			2.38
2	2.97*	34	.57*	3	2.40
3	3.30*	74	.82*	54	2.48
4	3.55	25	.95*	21	2.60

*significantly different $\alpha = .05$ (analysis of variance and Scheffe's test) flashes the number of flashes per flash pattern often increased: in single-flashing demes they became 2 pulsed, in triple-flashing demes they became 4 or 5 pulsed. One evening I succeeded in attracting a number of males to a flashlight which I held in the grass. When I removed the flashlight the flashing of these males attracted several other flying males. Both males and females produced repeated single flashes when handled and in other contexts.

Aggressive Mimicry

Females of *Photuris fairchildi* are aggressive mimics; they answer the flash signals of males of other species of fireflies mimicking their female signals and preying on those they attract. This behavior has been observed in other species of *Photuris* (Lloyd 1965; 1973). Several times I found *Photuris* females holding or standing near chewed-up males of *Pyractomena linearis* and *Pyractomena borealis.* The female responses of these 2 species are single flashes at response intervals of about 1.5 and 1 sec respectively. *Photuris* females commonly answered flashlight signals with single flashes (rarely more than 1) and at response intervals varying from 0.8 to over 4 sec but usually 1 to 1.5 sec. One evening I received several flash responses (at about 1 to 1.5 sec delays) from a *Photuris* female perched on a roadside plant. I left for a short time. When I returned I noted some erratic flashes from this plant. On investigation I found the female holding a newly captured male *Pyractomena borealis.* On another occasion I noted flash exchanges in the grass. A female answered the male with single flashes at short delays (1 to 1.5 sec) while he crawled toward her. When the flashing stopped I investigated and found a *Photuris* female holding a male *Pyractomena linearis.* Another evening a male *Photinus ardens* was flying over a grassy meadow producing a slow triple flash pattern. He received a response flash from the grass about 2 sec after his last flash and then landed. I turned on my flashlight expecting to collect a female *Photinus ardens* but found a *Photuris* female instead.

Sometimes *Photuris* females answered *Photuris* male flashes with single flashes but did not increase the number of flashes in succeeding responses. The male would hover, repeat his flash signal several times, then fly away. These females may have been aggressive females. The *Photuris* males apparently will not land unless the female response changes to a series of flashes.

Discussion

Courtship flash communication among *Photuris* fireflies has rarely been observed and remains a mystery in most species. Williams (1917) and Hess (1920) were convinced that flash communication was involved in courtship of *Photuris* fireflies, but they could not detect flash-answer communication as they did in other American fireflies. Flash-answer communication was later observed in *Photuris divisa* LeConte (Buschman 1972). In this species the female answered the male flash pattern with 1-6 pulses at a response interval of about 1.5 sec. Male *Photuris* fireflies of as many as 15 species (including *Photuris fairchildi*) can be attracted to answering flashlight signals (J. E. Lloyd, personal communication). In *Photuris fairchildi* the courtship flashing appeared to begin with flash-answer signals but then shifted to continuous flashing. Continuous flashing during courtship was also observed in other *Photuris* species by Hess (1920) and Barber (1951). Hess stated that "both continued to flash actively," and Barber stated that there was a "quickened repetition of the male's signals as he approached [the female] in a long oblique descent." The communicative parameters of these courtship exchanges are still not understood but flash-answer signals appear to be involved.

An understanding of courtship communication in *Photuris* fireflies is complicated by the fact that females of many species (e.g., *Photuris versicolor* and *Photuris fairchildi*) are aggressive mimics. Aggressive mimicry raises several questions about the flash behavior of these fireflies. Do aggressive mimics use their own courtship signals to attract prey? Do they prey on their own males as well as the males of other species? My observations indicate that in *Photuris fairchildi* the flash signals differ in the 2 situations. During aggressive mimicry the *Photuris* female answers males with single flashes usually at response intervals of 1 to 1.5 sec. During courtship the first female response may also be a single flash at a response interval of 1 to 1.5 sec but the number of flashes in her response increases as the dialogue proceeds until she appears to be flashing continuously. *Photuris* males will approach many kinds of flashes, but they apparently are less likely to land if the responses remain single flashes. They apparently can avoid predatory females by landing only for responses including a series of flashes. I have not observed *Photuris* females preying on males of their own species except in captivity, although J. E. Lloyd found a female *Photuris* eating a male *Photuris* in a site in northern Michigan where presumably only 1 species (*Photuris fairchildi*?, JEL det.) occurs (personal communication).

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